XXXVIII. *A Letter from Mr.* T. Melvil *to the Rev.* James Bradley, *D. D. F. R. S. With a Diſcourſe concerning the Cauſe of the different* Refrangibility *of the* Rays *of* Light.

SIR,

Read March 1, 1753. THO' I have not the honour of your acquaintance, I have preſumed to addreſs the incloſed paper to you, relating to optics and aſtronomy. The unwearied zeal which you have ſhewn, Sir, for the improvement of theſe ſciences, made me conclude, that whatever has an appearance of truth or novelty on ſuch ſubjects, tho' inconſiderable in itſelf, might not be unacceptable to you. Beſides, among all the ſocieties of the learned in Europe, I could think of no abler judge to conſult on theſe matters, than the author of the "Aberration of Light, "and of the Variation of the Preceſſion of the Equi-"noxes:" the two greateſt diſcoveries, without doubt, that have been made in aſtronomy for half a century. Perhaps you may be able, Sir, from the many accurate obſervations you have already made, to decide the queſtion relating to the velocity of light; or, at leaſt, to determine, whether the obſervation propoſed be practicable: for I am very ſenſible, that many obſervations, which appear eaſy in ſpeculation, cannot be put in execution.

If you find any thing in the incloſed worthy of the public view, you are at liberty to lay it, in whole, or in

in part, before the Royal Society, or to make what uſe of it you pleaſe. I am,

SIR,

Geneva, Feb. 2, 1753. Your moſt obedient humble ſervant,

T. Melvill.

Concerning the Cauſe of the different Refrangibility *of the* Rays *of* Light, *by Mr.* T. Melvill.

Read March 8, 1753. 1. IN order to account for the different refrangibility of the differently-colour'd rays, Sir Iſaac Newton †, and ſeveral of his followers, have ſuppoſed, that their particles are of different magnitudes or denſities; but if there be any analogy between the refractive power and gravity, it will produce equal velocities in all particles, whatever their magnitude or denſity be; and ſo all ſorts of rays would be equally bent from their right lined direction.

2. It ſeems therefore a more probable opinion, which others have advanced, that the differently-colour'd rays are projected with different velocities from the luminous body; the red with the greateſt, violet with the leaſt, and the intermediate colours with intermediate degrees of velocity; for, on this hypotheſis it is manifeſt, that they will be differently refracted

† Newton's Optics, Query 29.

refracted in the priſmatic order, according to obſervation.

3. On ſuppoſition, that the different refrangibility of light ariſes ſolely from the different velocities of the rays before incidence, theſe velocities muſt be to one another nearly as their ſines of refraction. — I ſay nearly; for their exact proportion cannot be diſcovered, but by the ſolution of the following problem, which I take this opportunity of propoſing to the learned:

If two bodies fall, in equal angles of incidence, on a ſpace terminated by parallel planes, in which any power acts perpendicularly to the planes (according to the hypotheſis in Prop. 94, Lib. I. of the *Principia*) the ratio of the ſines of emergence to the common ſine of incidence, and conſequently to one another, being given, to determine the proportion of their velocities at the time of their incidence on the firſt plane.

4. Their velocities in any given medium (ſuppoſe air) being once determined, their velocities in any other may be eaſily diſcover'd; for they are to thoſe in air as the ſine of incidence to the ſine of refraction, when the ray paſſes from air into the other medium †.

5. While the differently-colour'd rays are ſuppoſed to move with one common velocity, any pulſes, excited in the æthereal medium, muſt overtake them at equal

† Principia, Phil. Nat. Prop. 95, Lib. I.

equal diſtances; and therefore the intervals of the fits of reflexion and tranſmiſſion, if they ariſe in this manner, as Sir Iſaac conjectures, would be all equal: but if the red move ſwifteſt, the violet ſloweſt, and the intermediate colours with intermediate velocities, it is plain, that the ſame pulſes muſt overtake the violet ſooneſt, the other colours in their order, and laſt of all the red; that is, the intervals of the fits muſt be leaſt in the violet, and gradually greater in the priſmatic order, agreeably to obſervation.

6. Let c denote the velocity of the æthereal pulſes, V the velocity of red light, and U that of violet; I and $\mathcal{J}$ the intervals of their fits, and D the diſtance between two ſucceeding pulſes: it is plain, from the nature of Newton's hypotheſis, that I is to D, as V to $C-V$: and again, D to $\mathcal{J}$ as $C-U$ to U: therefore, *ex æquo*, I is to $\mathcal{J}$, as $CV-VU$ to $CU-VU$, from which we have the equation $C=\frac{I-\mathcal{J}\times VU}{I\times U-\mathcal{J}\times V}$ Therefore, as the proportion between the intervals of the fits in red and violet, can be aſſigned by experiment, and the proportion of their velocities in any medium likewiſe, by Art. 4. the velocity of the æthereal pulſes may be eaſily computed. The velocities of the red and violet in air are nearly as 78 and 77. In the celeſtial ſpaces they are leſs, but almoſt in the ſame proportion; the intervals of their fits are by experiment as 100 and 63 †, from whence, by the canon now laid down, the velocity of the æthereal pulſes in the celeſtial ſpace is found to be to that of red

† Newton's Optics, Lib. II. Part I. Obſ. 14.

red light as 79763 to 78000. As light moves from the ſun to us, by Dr. Bradley's accurate eſtimation, in 8′ 12″ (*a*), the pulſes of the æthereal fluid muſt be propagated thro' the ſame ſpace in about 8′ 1″.

7. Hence alſo may be determined, in known meaſures, the diſtance between two ſucceeding æthereal pulſes for $D = \frac{CI - VI}{V}$.

8. Upon the hypotheſis of the different velocities of different colours, we may underſtand, at leaſt in general, the reaſon of the ſtrange analogy, diſcover'd by Sir Iſaac, between the intervals of the fits, and the ſpaces occupied by the ſeveral colours in the ſpectrum (a thing hitherto unexplained (*b*); ſince, from the velocities of the ſeveral rays, upon which depend the intervals of the fits, as has been now explained, ariſe likewiſe their ſeveral degrees of refrangibility.

9. But, as it is of great conſequence in philoſophy, to diſtinguiſh between facts and hypotheſes, however plauſible, I obſerve, that the various refrangibility, reflexibility, and inflexibility, of the different colours, and their alternate diſpoſitions, at equal intervals, to be reflected and tranſmitted, which are the whole ground-work of the Newtonian ſyſtem, are to be conſider'd as undoubted facts, deduced from experiment; but that the velocities of different rays are different in the manner now deſcrib'd, is no more than probable conjecture: and tho' this point ſhould be decided, by a method that we are now to propoſe, it

(*a*) Eames's Abridg. Tranſact. Vol. VI. p. 157.

(*b*) Compare Newt. Opt. Book I. Part 2. Prop 3. with Book II. Part 3. Prop. 16.

it would ſtill remain uncertain, whether the fits of reflexion and tranſmiſſion conſiſt in an alternate acceleration and retardation of the particles of light, or in ſomething elſe. For inſtance, it might be ſuppoſed, that every particle of light has two contrary poles, like a loadſtone; the one of which is attracted by the parts of bodies, and the other repell'd; and that, beſides their uniform rectilineal motion, the particles of differently-colour'd rays revolve in different periods round their centers; for thus their friendly and unfriendly poles being alternately turned towards the ſurfaces of bodies, they might be alternately diſpoſed to reflexion and tranſmiſſion, and that at different intervals, in proportion to the periods of their rotation. Laſtly, tho' it were proved, that the fits do proceed from an alternate acceleration and retardation of the particles of light, it would ſtill be no more than probable conjecture, that this is brought about by pulſes excited in the æthereal medium. Nay there are ſome circumſtances in theſe phænomena, that ſeem hardly intelligible by that hypotheſis alone: as, Why the intervals of the fits are leſs in denſer mediums (*a*); and, Why they increaſe ſo faſt, and in ſo intricate a proportion, according to the obliquity of incidence (*b*).

10. By Dr. Bradley's beautiful theory of the aberration of light, the ſtars appear to be removed from their true place to a certain diſtance, according to the proportion which the tranſverſe motion of the ſpectator's eye bears to the velocity of light. It is plain therefore,

(*a*) Newt. Opt. Book II. Part 3. Prop. 17.
(*b*) Prop. 15. *ibidem.*

therefore, that, on our hypotheſis, any ſtar muſt have a different apparent place for every different colour; that is, its apparent diſk muſt be drawn out by the aberration into a longitudinal form, reſembling the priſmatic ſpectrum, having its red extremity neareſt its mean place. In the ſtars ſituated about the pole of the ecliptic, its length ſhould continue always the ſame, tho' directed along all the different ſecondaries of the ecliptic in the courſe of a year: but in thoſe which lie in or near the plane of the ecliptic, it ſhould be greateſt at the limits of the eaſtern and weſtern aberrations, the ſtar recovering its colour and figure, when the true and mean places coincide. But there is no hope of diſcovering, whether our ſyſtem be true or falſe, by this conſequence of it: for the greateſt length of the dilated diſk being to the whole aberration, as the difference of the velocity of the red and violet to the mean velocity of light, *i. e.* but about a 77th part of it, cannot much exceed the fourth part of a ſecond.

11. The time which the extreme violet light takes in arriving from any diſtance to the eye, will be to that which the extreme red takes in coming from the ſame, as 78 to 77. If Jupiter be ſuppoſed in a quadrate aſpect with the ſun, in which poſition the eclipſes of his ſatellites are moſt commodiouſly obſerved, his diſtance from the earth being nearly equal to his diſtance from the ſun, light takes about 41′ in paſſing from him to the earth; therefore the laſt ſenſible violet-light, which the ſatellite reflects before its total immerſion into Jupiter's ſhadow, ought to continue to affect the eye for a 77th of 41′; that is, about 32″ of time after the laſt ſenſible red light is gone. It is therefore a certain conſequence of our

hypotheſis, that a ſatellite, ſeen from the earth, ought to change its colour about half a minute before its total immerſion, from white to a livid greeniſh colour; thence into blue, and at laſt evaniſh in violet. I need hardly obſerve, that the ſame phænomenon muſt take place in the time of emerſion by a contrary ſucceſſion of colours, beginning with red, and ending in white.

12. If this phænomenon be perceived by aſtronomers, we ſhall have a direct proof of the different velocities of the differently-colour'd rays, and, conſequently, a mechanical account of their different degrees of refrangibility; for I ſee not, to what other cauſe ſuch an appearance could be reaſonably aſcribed. If it be not, we may conclude, that rays of all colours are emitted from the luminous body with one common velocity.

Geneva, Feb. 1, 1753.

T. Melvill.

This paper was delivered to Mr. Short, in order to attend to the particular obſervation of Jupiter's ſatellites recommended by Mr. Melvill, who after ſome time made the following report to the Society.

EVER ſince this paper of Mr. Melvill's was put into my hands, I have carefully attended the emerſions of Jupiter's firſt ſatellite thro' a reflecting teleſcope of four feet focal length, and with a proper magnifying power; but I have not perceived the leaſt alteration in the colour of the light reflected by the ſatellite,

ſatellite, except in quantity. It may indeed be obſerved, that theſe emerſions are ſeen ſooner or later thro' teleſcopes of different lengths, and by eyes of different goodneſs: and it may therefore be alleged, that there is a certain quantity of time elapſed between the very firſt emerſion of the ſatellite, and the inſtant when it is perceived by the very beſt eye, aſſiſted by the beſt teleſcope; and that, during this interval, the ſucceſſion of colours, above-mention'd, is perform'd. But our author, in conſequence of his hypotheſis, ſays, that this ſucceſſion of colours may be perceived for the ſpace of 32″ after the firſt emerſion of the ſatellite; and I am fully ſatisfied, from repeated obſervations, that the quantity of time elapſed from the very firſt emerſion of the ſatellite, till it is perceived by a good eye, aſſiſted by a good teleſcope, can amount only to a very few ſeconds. So that, upon the whole, we may conclude, that it does not appear, by the obſervations of the emerſions of the firſt ſatellite of Jupiter, that the rays of different colours move with different degrees of velocity.

But our author's concluſion, that, if the rays of light emitted from Jupiter's ſatellites, at the time of their immerſion and emerſion, ſhould not be found of different colours, the rays of all colours emitted from luminous bodies will have one common velocity, ſeems only to hold good, on a ſuppoſition, that light is propagated by a continued motion, in the manner of a projectile.

Dr. Knight, in his treatiſe on attraction and repulſion (Prop. 69.) has conſider'd the propagation of light, as performed by vibrations in an elaſtic fluid, in the ſame manner as ſound is produced by vibrations

vibrations in the air: and he thinks, that it is as eaſy to conceive how the velocities of the particles of light may be different, and yet take up equal times in propagating their motion from one to another through a given ſpace, as to explain how ſounds of different tones move with equal velocities. In accounting for both, he ſhews, that, in a ſeries of particles, which mutually repel each other, the greater their velocity, the nearer they will approach other, in communicating their motions from one to another; and conſequently each of them muſt move thro' a greater ſpace in ſo doing: wherefore the ſame time may be ſpent in propagating a ſucceſſive motion thro' a ſeries of particles, whoſe velocity is greater, if each particle has to move thro' a greater ſpace, as is ſpent, where the velocity of each particle is leſs, but is continued thro' a leſs ſpace. The dilemma, to which our author's reaſoning ſeems to have reduced the doctrine of refrangibility, may therefore be conſider'd as a probable argument for adopting this hypotheſis of the propagation of light thro' an elaſtic medium.

XXXIX. *The Caſe of the Operation for the* Empyema, *ſucceſsfully performed by* Joſeph Warner, *F. R. S. and Surgeon to* Guy's Hoſpital.

Read June 28, 1753. ON the 19 of March 1752, I did myſelf the honour of communicating to the Royal Society the caſe of John Hines, on whom I had performed the operation for the empyema